

### Technical Meeting series W and Hydrogen in Edge Plasmas

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### TM on W and hydrogen – brief history



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- ✤ 2010 2015: CRP "Collisional Data for W from 1 eV 20 keV" (\*)
- 2011 2015: CRP "A+M data for H & He in fusion plasma"
- Collaboration with Forschungszentrum Jülich, Germany
- Planning of new TM on W commenced at ICTP-IAEA Workshop 2019

"Review, evaluate and recommend fundamental data on W and hydrogen, their atoms and molecules in edge plasmas"

- Participants and audience:
  - ✓ Plasma modellers
  - Experimentalists
  - ✓ Theorists

https://amdis.iaea.org/meetings/tm-tungsten-hydrogen/

- 2020: in-person meeting at FZJ
  - 29 presentations, 16 Member States, ITER



### 2021: rescheduled event

- Date: from 28 March 1 April
- Virtual meeting instead of in-person event
- 24 presentations, 16 Member States, ITER
- > 40 participants online



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https://amdis.iaea.org/meetings/tm-tungsten-hydrogen/

### Agenda: 5 scientific sessions

- **A. EXP/1 fusion devices**: tokamaks, linear plasmas, stellarators
- B. MOD/1 fusion devices: plasma simulations and modelling
- C. EXP/2 A+M data: A+M experiments, cross-sections
- D. MOD/2 A+M data: A+M modelling
- E. CR: collisional-radiative modelling
- F. summary session
  - summaries & reports by session chairs
  - discussion and outlook



### W source determination

- W erosion data for CR modelling
- W ground state population / metastables
- W local or prompt redeposition after sputtering
- $\circ$  WD release and excitation of D<sub>2</sub>

### W influx transport

- Use of W UTA (unresolved transition array) at ~5 nm and ~20 nm
- Line identification and utilization of WV WIX
- Observation of forbidden transitions in the visible range
- Data for low ionization states of W (W, W<sup>+</sup>, W<sup>2+</sup>, W<sup>3+</sup>, ...) for divertor
- Higher ionization states of W for quantification in confined plasma

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### Hydrogen recycling and needs for improved CR modelling

- Need for more vibrationally resolved data than currently available
- Rotationally resolved data
- Isotopically resolved data
- Ensure consistency of present data
- Synthesize molecular spectrum in model to compare with experiment
- Charge transfer of W<sup>0</sup> + H<sup>+</sup> (and other CX pairs) in edge/divertor
- Cross-sections for ion impact processes (excitation, ionization, CX)
- Open issue: isotopes and mixed molecules.
  - Limited data on T, TH and TD
  - experiments at JET 2021



Conclusions (session chairs and Scientific Committee)

- ✓ Need for IAEA-led *Working Groups*:
  - 1. A+M Data Recommendation & Validation for W and hydrogen
  - 2. Plasma Experiments and Comparison with CR Models
    - a) W and hydrogen experiments with fusion devices
    - b) Photon opacity models for hydrogenic A+M species
  - 3. Plasma-surface Processes: Properties, Trends, Underlying Effects
  - >*WG* members: GNAMPP, Tungsten TM participants, other IAEA networks
  - ITER representative(s) at WG activities, meetings, etc. Permanent membership.
  - Recommendation for meeting series; next in Dec 2021

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Conclusions (session chairs and Scientific Committee)

Summary report of the Joint IAEA-FZJ technical meeting on the collisional-radiative properties of tungsten and hydrogen in edge plasmas of fusion devices



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#### Abstract

This report summarizes the contributions and conclusions presented at a Joint IAEA-FZJ technical meeting on collisional-radiative properties of tungsten and hydrogen in fusion edge plasmas, held as a virtual meeting from 29 March – 1 April 2021. Meeting brought together over 40 participants from 15 IAEA member states from all over the world to discuss and review fundamental data concerning tungsten, hydrogen, their ions and molecules in the edge plasma region of experimental fusion devices with a view to quantify and reduce uncertainties in the modelling of its collisional. radiative and plasma-material interaction properties.

## 2021: TM on W and hydrogen – WG1 and WG2



- Meeting for *Working Groups*
  - 1. A+M Data Recommendation & Validation for W and hydrogen
  - 2. Plasma Experiments and Comparison with CR Models
    - a) W and hydrogen experiments with fusion devices
    - b) Photon opacity models for hydrogenic A+M species
- Joint meeting with GNAMPP network
  - Date: 6 8 December; virtual meeting with open invitation
  - 2<sup>nd</sup> GNAMPP meeting
  - 23 presentations, 68 participants, 21 Member States, ITER

>WG members: GNAMPP, Tungsten TM participants, other IAEA networks

GNAMPP - Global Network for A+M Physics of Plasmas https://amdis.iaea.org/GNAMPP/ https://amdis.iaea.org/meetings/gnampp-2/

### 2021: TM on W and hydrogen – WG1 and WG2



### WG1: A+M Data Recommendation & Validation

- > chair: U. Fantz, D. Wünderlich
- > 14 presentations (CX, elastic scattering models, reactive *e* collisions, CR models,...)
- > dialogue between data providers and data users

List of collisional cross section and rate coefficient data (w/ and w/o W) required by modellers

GNAMPP - Global Network for A+M Physics of Plasmas https://amdis.iaea.org/GNAMPP/ https://amdis.iaea.org/meetings/gnampp-2/ Higher (than 10) ionized states not listed below are not so important for the SOL (edge plasma) state, although are important for overal W transport.

Processes	conta	ining	tungsten	

Species A (ionization	Process type	Energy range	Priority (comment)
state) / B (ionization			
state)			
H, D, T (1) / W (0)	Charge exchange	0.1 – 1 000 eV	High
H, D, T (1) / W (0)	elastic	0.1 – 1 000 eV	moderate
H, D, T (0) / W (i)	Charge exchange	0.1 - 4000 eV	High (i= 1, 2,,10)
el. / W (i)	recombination	0.1 – 4 000 eV	High (i= 1, 2,,10)
el. / WA (i)	Dissociation	E_threshold – 4 000 eV	Moderate (i= 1, 2,
			,10), A= H, D, T, Ne,
			N, O
el. / WA (i)	Dissociation with	E_threshold – 4 000 eV	Moderate (i= 1, 2,
	ionization		,10), A= H, D, T, Ne,
			N, O
el. / WA (i)	Dissociation with	E_threshold – 4 000 eV	Moderate (i= 1, 2,
	recombination		,10), A= H, D, T, Ne,
			N, O
el. / WA (i)	Dissociation with	E_threshold – 4 000 eV	Moderate (i= 1, 2,
	recombination		,10), A= H, D, T, Ne,
			N, O
H, D, T (1) / WA (0)	elastic	0.1 – 1 000 eV	Moderate A= H, D, T,
			Ne, N, O
H, D, T (1) / WA (0)	dissociation	E_threshold – 1 000 eV	Moderate A= H, D, T,
		_	Ne, N, O
H, D, T (1) / WA (0)	Dissociation with	E_threshold – 1 000 eV	Moderate A= H, D, T,

### 2021: TM on W and hydrogen – WG1 and WG2



WG1: A+M Data Recommendation & Validation

> chair: U. Fantz, D. Wünderlich

> 14 presentations (CX, elastic scattering models, reactive *e* collisions, CR models,...)

bialogue between data providers and data users

WG2a: W and hydrogen experiments with fusion devices

> permanent chair: S. Brezinsek

> 6 presentations (NIFS, LHD, WEST, SH-HtscEBIT, Justus Liebig Univ)

WG2b: Photon opacity mod. for hydrogenic A+M species

> permanent chair: S. Wiesen

> 3 presentations (JET, line shape model development (AMU))

GNAMPP - Global Network for A+M Physics of Plasmas https://amdis.iaea.org/GNAMPP/ https://amdis.iaea.org/meetings/gnampp-2/

- WG3: Plasma-surface Processes: Properties, Trends, Underlying Effects
- ☐ Technical Meeting, 11 12 April, Aix-en-Provence
  - Outcome of IAEA co-organized workshop series MoD-PMI "Models and Data for Plasma-Material Interaction"
  - Topic: "Effects of Hydrogen Supersaturation and Defect Stabilization in Nuclear Fusion Devices"
  - in-person event only; local organizer Aix Marseille Univ
  - 19 participants, 5 Member States, ITER
  - Agenda: 2 sessions, 3 introductory talks/session



(chair: K. Heinola)

Exp

Theory



□ Technical Meeting, 11 – 12 April, Aix-en-Provence

Topic: "Effects of Hydrogen Supersaturation and Defect Stabilization in Nuclear Fusion Devices"





Technical Meeting, 11 – 12 April, Aix-en-Provence

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## TM on W and hydrogen – outlook to 2022 & 2023

2022: CM for WG3: erosion W surfaces, WH formation, redeposition

2023: Joint WG1, WG2 and WG3 meeting at APiP Conference

Atomic Process	es in Plasmas			
15–19 May 2023 Vienna International Centre Europe/Vienna timezone	Enter your search term Q			
Overview	Welcome to the 21st International Conference on Atomic Processes in Plasmas. APIP will be held at the			
Scientific Programme	Headquarters of the International Atomic Energy Agency (IAEA), in the Vienna International Centre,			
Timetable	Vienna Austria from 15 – 19 May 2023.			
Practical Information	There is no registration fee for this event.			
History	A limited number of grants for financial assistance with travel and accommodation are available for			
Contribution List	eligible participants.			
Contact				
s/apip21/ (ept/238/				

APiP 2023 https://amdis.iaea.org/meetings/apip21/ https://conferences.iaea.org/event/238/ (Q3/Q4 tbc)

(tbc)



# Thank you!